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PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application of:

Applicant	:	Brian Mitchell
Serial No.	:	09/921,043
Filed	:	August 2, 2001
Title	:	LOUDSPEAKER
Docket No.	:	534334-010

Assistant Commissioner for Patents
Washington, D.C. 20231

SUBMISSION OF PRIORITY DOCUMENT

Pursuant to the claim for priority under 35 U.S.C. §119 made in the Declaration in the above-identified application, the following priority document is submitted:

Country	Application No.	Filing Date
Great Britain	0018831.8	August 2, 2000

No fee is required. The Commissioner is authorized to charge any additional fees required by this paper (including the fee for any additional extension of time) or to credit any overpayment to Deposit Account No. 20-0809.

Respectfully submitted:

By: _____
Theodore D. Lienesch
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NP10 8QQ

I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation and Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein together with the Statement of inventorship and of right to grant of a Patent (Form 7/77), which was subsequently filed.

In accordance with the Patents (Companies Re-registration) Rules 1982, if a company named in this certificate and any accompanying documents has re-registered under the Companies Act 1980 with the same name as that with which it was registered immediately before re-registration save for the substitution as, or inclusion as, the last part of the name of the words "public limited company" or their equivalents in Welsh, references to the name of the company in this certificate and any accompanying documents shall be treated as references to the name with which it is so re-registered.

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Signed D Evans.

Dated 1 August 2001

CERTIFIED COPY OF PRIORITY DOCUMENT

Patents Form 1/77

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02AUG00 E557492-2 D01063
P01/7700 0.00-0018831.8

THE PATENT OFFICE
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(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

The Patent Office

Cardiff Road
Newport
South Wales
NP10 8QQ

1. Your reference

JSR.P51220GB

2. Patent application number
(The Patent Office will fill in this part)

0018831.8

- 2 AUG 2000

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

Fane Acoustics Limited
Unit 1, Milshaw Park Avenue
Milshaw Park Industrial Estate
Leeds LS11 0LR

Patents ADP number *(if you know it)*

7952831001

If the applicant is a corporate body, give the country/state of its incorporation

British

4. Title of the invention

Loudspeaker

5. Name of your agent *(if you have one)*

Marks & Clerk

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

Marks & Clerk
4220 Nash Court
Oxford Business Park South
Oxford
OX4 2RU

Patents ADP number *(if you know it)*

727 1125 001

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*

a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
c) any named applicant is a corporate body.
See note (d))

Yes

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	(none)
Description	8
Claim(s)	3
Abstract	1
Drawing(s)	4

10. If you are also filing any of the following, state how many against each item.

Priority documents	
Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
Request for preliminary examination and search *(Patents Form 9/77)*	1
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. I/We request the grant of a patent on the basis of this application.

Signature Marks & Clerk — Date 1 August, 2000

12. Name and daytime telephone number of person to contact in the United Kingdom: J S Robinson - 01865 397900

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Notes

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The Patent Office

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Statement of inventorship and of right to grant of a patent

The Patent Office

Cardiff Road
Newport
Gwent NP9 1RH

1. Your reference

   JSR.P51220GB

2. Patent application number
   (if you know it)

   0018831.8

3. Full name of the or of each applicant

   Fane Acoustics Limited

4. Title of the invention

   Loudspeaker

5. State how the applicant(s) derived the right from the inventor(s) to be granted a patent

   By virtue of assignment.

6. How many, if any, additional Patents Forms 7/77 are attached to this form?
   (see note (c))

   None

7. I/We believe that the person(s) named over the page *(and on any extra copies of this form)* is/are the inventor(s) of the invention which the above patent application relates to.

   Signature: Marks & Clerk.

   Date: 11 August 2000

   Marks & Clerk

8. Name and daytime telephone number of person to contact in the United Kingdom

   J S Robinson - 01865 397900

Notes

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c) If there are more than three inventors, please write the names and addresses of the other inventors on the back of another Patents Form 7/77 and attach it to this form.

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Enter the full names, addresses and postcodes of the inventors in the boxes and underline the surnames

Brian Mitchell
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07963960001

Patents ADP number *(if you know it)*:

Patents ADP number *(if you know it)*:

Patents ADP number *(if you know it)*:

Reminder

Have you signed the form?

LOUDSPEAKER

The present invention relates to a low frequency loudspeaker. Such a loudspeaker may be used, for example, as part of a system covering the audible frequency range for domestic or professional applications.

As is well known in the field of loudspeaker design, in order to produce acceptable output at low frequencies, for example in the range from about 50Hz to about 200Hz, it is necessary to prevent the acoustic energy generated by the rear of a cone diaphragm of an electromagnetic driver from interfering destructively with the acoustic output from the front of the cone diaphragm. One technique for achieving this involves mounting the driver on a large baffle so as to increase the acoustic path length of acoustic radiation from the rear of the cone diaphragm to the front thereof. Another known technique involves mounting the driver in an enclosure which may or may not be sealed. Such enclosures generally contain material for at least partially damping the acoustic output from the rear of the cone diaphragm.

Although these known measures allow the low frequency output of the loudspeaker to be extended, such arrangements are generally large and heavy. Also, the resulting desired acoustic output tends to be subjected to "colourations", for example substantial variations in the frequency response. Reducing the size of an enclosure also reduces the electro-acoustic efficiency at relatively low frequencies.

According to the invention, there is provided a low frequency loudspeaker comprising: a driver having a cone diaphragm with an inner suspension and an outer suspension; and a further diaphragm mechanically connected to the cone diaphragm between the inner and outer suspensions and having an edge which is mechanically terminated, the further diaphragm having an aperture for the passage of acoustic energy from the cone diaphragm and extending laterally outwardly of the cone diaphragm.

The term "mechanically connected" as used herein refers to a connection in which momentum is at least partially transmitted through and by means of a connection. The term "mechanically terminated" as used herein means not completely free to move without constraint. Mechanical termination thus partly or completely restricts or reduces movement.

The further diaphragm may be substantially flat.

The mechanical termination may be a substantially rigid termination or may be a resilient termination.

The mechanical connection between the cone diaphragm and the further diaphragm may be substantially rigid. The cone diaphragm may be directly connected to the further diaphragm or may be connected by a substantially rigid intermediate member.

The mechanical connection between the cone diaphragm and the further diaphragm may be resilient and may be by a resilient intermediate member.

The intermediate member may be annular.

The intermediate member may be of a cellular material, for example polystyrene foam.

The cone diaphragm may be connected to the further diaphragm substantially at or adjacent the edge of the aperture.

The cone diaphragm may be connected to the further diaphragm adjacent the outer suspension.

The inner and outer suspensions may be connected to the cone diaphragm at inner and outer, edges respectively, of the cone diaphragm.

The further diaphragm may be made of a laminar material, which may be a plastics material and which may comprise first and second layers connected together by a corrugated layer.

The further diaphragm may have a lateral dimension which is substantially equal to or greater than twice a lateral dimension of the cone diaphragm. The lateral dimension of the further diaphragm may be less than three times the lateral dimension of the cone diaphragm.

The further diaphragm may be substantially rectangular and may be mechanically terminated at its edge by a substantially rectangular frame having inside corners which are rounded in a transverse plane.

The driver may comprise an electromagnetic motor for driving the cone diaphragm. The driver may comprise a chassis defining a substantially frusto conical volume in which the motor is disposed.

It is thus possible to provide a low frequency loudspeaker which is capable of producing a relatively smooth and uncoloured acoustic output at low frequencies without requiring a large baffle or a large and/or heavy enclosure. Furthermore, this may be achieved with an acceptable electro-acoustic efficiency. Such a loudspeaker is suitable for use, for example, as a "woofer" in a loudspeaker system for domestic use. However, such a loudspeaker is also suitable for use in professional applications, such as public address or sound reinforcement systems and is capable of providing a high level of relatively low frequency acoustic output at relatively high electro-acoustic efficiency. It is further possible to provide a low frequency loudspeaker having an extended upper frequency range and operation from about 50Hz to about 2000Hz is believed possible.

The invention will be further described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a vertical cross-sectional view of a low frequency loudspeaker constituting an embodiment of the invention;

Figure 2 is a horizontal cross-sectional view of the loudspeaker of Figure 1;

Figure 3 is a front view of part of the loudspeaker of Figure 1; and

Figure 4 is a horizontal cross-sectional view of a loudspeaker constituting a further embodiment of the invention.

Like reference numerals refer to like parts throughout the drawings.

The loudspeaker shown in Figures 1 and 2 comprises a supporting frame having a vertical plate 1 rigidly connected to top and bottom plates 2 and 3. An electromagnetic moving coil driver 4 is fixed to the plate 1 and comprises a chassis 5 which defines a frusto conical volume containing a motor 6. The motor is of conventional type and comprises a permanent magnet with a centre pole piece and annular outer pole piece defining an annular magnetic gap. A voice coil wound on a former is disposed in the magnetic gap.

The former extends forwardly of the magnetic gap as illustrated at 7 and is held in place transversely with respect to the axis of the driver by an inner suspension 8, which allows the voice coil 7 to move longitudinally with respect to the driver axis. The front of the voice coil 7 is fixed to the inner end of a cone diaphragm 9, for example made of paper, plastics, or a composite material.

The outer edge of the cone diaphragm 9 is fixed, for example by means of an adhesive, to the edge 10 of an aperture formed in a further diaphragm 11. The edge 10 of the aperture is also fixed to an outer suspension or roll surround 12. The suspensions 8 and 12 provide a restoring force which urges the voice coil on the former 7 to a rest position which is longitudinally substantially centred in the magnetic gap of the motor 6.

The further diaphragm 11 is made of a relatively light material having a degree of rigidity which makes it substantially capable of performing pistonic movement but with a degree of flexibility such that the amount of movement reduces with distance from the aperture. For example, the further diaphragm 11 may be made of a laminar plastics material of a type known as Corex (TM), which comprises first and second plastics layers connected together by a corrugated plastics layer.

The cone diaphragm 9 typically has a diameter which is nominally between about 6 inches (about 15cm) and about 18 inches (about 45cm). The further diaphragm 11 may have any desired shape but the example illustrated in the drawings is square. In the case of a "10 inch" cone driver 4, each side of the further diaphragm 11 is 22 inches (about 55cm) in length. In general, it is believed that the lateral dimension of the further diaphragm 11 should be about twice that of the cone diaphragm 9 or perhaps a little more. It may be preferable for the lateral dimension of the further diaphragm 11 to be less than three times the lateral dimension of the cone diaphragm 9. However, these relative dimensions may depend on various factors, for example the properties of the material of which the further diaphragm 11 is made.

The edges of the further diaphragm 11 are mechanically terminated by being connected to a rectangular frame 15, which is fixed to the top and bottom plates 2 and 3. As shown in Figure 3, the inner corners of the frame 15 are rounded. The connection between the edges of the further diaphragm 11 and the frame 15 may be direct, for example by means of adhesive, or maybe via an intermediate member as illustrated at 16. The termination may be rigid such that the edges of the further diaphragm 11 are substantially prevented from moving. Alternatively, the connection may have at least some degree of resilience so as to permit some movement of the edges of the further diaphragm 11. The intermediate member 16 may be of any suitable material, depending on the specific requirements of the embodiment, and an example of a material which may be suitable is polystyrene foam.

In use, the voice coil on the former 7 of the driver 4 is connected to a suitable voltage source, for example the output of a power amplifier (directly or via a "crossover filter") and performs substantially pistonic motion within the magnetic gap of the motor 6. This movement is transmitted directly to the conical diaphragm 9, which ideally also performs pistonic movement although, in practice, pure pistonic movement cannot generally be achieved throughout a desired frequency range of operation. The outer edge of the cone diaphragm 9 transmits the movement to the further diaphragm 11. Thus, substantially the whole front of the loudspeaker is an acoustically radiating surface. It has been found that this arrangement provides good low frequency extension and, in particular, permits a low frequency loudspeaker to be produced without requiring an enclosure or a large baffle. The loudspeaker may therefore be relatively compact and relatively light, thus easing handling. Also, colourations associated with enclosures are substantially eliminated so that high quality low frequency sound may be produced.

The frame comprising the vertical plate 1 and the top and bottom plates 2 and 3 support the loudspeaker but do not perform any substantial acoustic function. Figure 2 illustrates a cover or sleeve 18 which visually encloses the elements of the loudspeaker but which is acoustically substantially transparent. The sleeve 18 performs protective and decorative functions but does not perform any substantial acoustic function and, in particular, does not act as an enclosure.

The loudspeaker shown in Figure 4 differs from that shown in Figures 1 and 2 in that the cone diaphragm 9 is connected to the further diaphragm 11 at or adjacent the edge 10 of the aperture therein by an intermediate member 20. The intermediate member 20 is annular and provides a rigid or resilient connection between the cone diaphragm 9 and the further diaphragm 11. An example of a suitable material for the intermediate member 20 is polystyrene foam.

Various factors determine the performance achieved by the loudspeaker. These include the sizes of the cone diaphragm 9 and the further diaphragm 11, the properties of the materials of the diaphragms, the degree of resilience in the connection between the cone

diaphragm 9 and the further diaphragm 11, and the degree of resilience in the mechanical termination of the edges of the further diaphragm 11. For example, it has been found that a relatively rigid connection between the diaphragms 9 and 11 and a relatively rigid termination of the edges of the further diaphragm 11 provide better high frequency extension and a better transient performance. For example, it may be pssible to achieve operation in a frequency range extending to about 2000Hz. More resilience in the connection and/or in the edge termination tends to decrease the high frequency extension and to reduce the low frequency transient response but provides a more extended low frequency response. The material of the further diaphragm 11 is required to have a sufficient degree of mechanical stability while being sufficiently resilient to allow the inner portions of the further diaphragm 11 to move further than the outer portions or the edge. The mechanical properties of the further diaphragm 11 may thus be varied to allow further "tuning" of the sound produced by the loudspeaker.

The driver 4 is illustrated as having the motor 6 within the frusto conical volume defined by the chassis 5 and this gives a relatively compact arrangement. However, conventional drivers in which the motor extends to the rear of the chassis may also be used.

It is thus possible to provide a low frequency loudspeaker which dispenses with the need for large baffles and any type of enclosure. Colourations associated with enclosures may thus be reduced or substantially eliminated and a relatively compact and light-weight arrangement may be provided for convenience of handling, for example in the case of a public address system, and for convenience of location, for example in a domestic environment. The electro-acoustic efficiency is acceptable and may be comparable to conventional arrangements so that no unusual power amplifier drive capabilities are required. The loudspeaker may thus be readily incorporated into a full-range multiple loudspeaker system, for example comprising in addition one or more high frequency loudspeakers or "tweeters" and one or more mid-range loudspeakers. Such a loud speaker is capable of covering the same range of frequencies as a conventional type of low frequency loudspeaker, for example from about 50Hz to about

200Hz, but may be capable of a more extended high frequency response, perhaps to as much as 2000Hz.

CLAIMS:

1. A low frequency loudspeaker comprising: a driver having a cone diaphragm with an inner suspension and an outer suspension; and a further diaphragm mechanically connected to the cone diaphragm between the inner and outer suspensions and having an edge which is mechanically terminated, the further diaphragm having an aperture for the passage of acoustic energy from the cone diaphragm and extending laterally outwardly of the cone diaphragm.

2. A loudspeaker as claimed in claim 1, in which the further diaphragm is substantially flat.

3. A loudspeaker as claimed in claim 1 or 2, in which the mechanical termination is a substantially rigid termination.

4. A loudspeaker as claimed in claim 1 or 2, in which the mechanical termination is a resilient termination.

5. A loudspeaker as claimed in any one of the preceding claims, in which the mechanical connection between the cone diaphragm and the further diaphragm is substantially rigid.

6. A loudspeaker as claimed in claim 5, in which the cone diaphragm is directly connected to the further diaphragm.

7. A loudspeaker as claimed in claim 5, in which the cone diaphragm is connected to the further diaphragm by a substantially rigid intermediate member.

8. A loudspeaker as claimed in any one of claims 1 to 4, in which the mechanical connection between the cone diaphragm and the further diaphragm is resilient.

9. A loudspeaker as claimed in claim 8, in which the cone diaphragm is connected to the further diaphragm by a resilient intermediate member.

10. A loudspeaker as claimed in claim 7 or 9, in which the intermediate member is annular.

11. A loudspeaker as claimed in any one of claims 7, 9 and 10, in which the intermediate member is made of a cellular material.

12. A loudspeaker as claimed in any one of the preceding claims, in which the cone diaphragm is connected to the further diaphragm substantially at or adjacent the edge of the aperture.

13. A loudspeaker as claimed in any one of the preceding claims in which the cone diaphragm is connected to the further diaphragm adjacent the outer suspension.

14. A loudspeaker as claimed in any one of the preceding clams, in which the inner and outer suspensions are connected to the cone diaphragm at inner and outer edges, respectively, of the cone diaphragm.

15. A loudspeaker as claimed in any one of the preceding claims, in which the further diaphragm is made of a laminar material.

16. A loudspeaker as claimed in claim 15, in which the laminar material comprises first and second layers connected together by a corrugated layer.

17. A loudspeaker as claimed in claim 15 or 16, in which the laminar material is a plastics material.

18. A loudspeaker as claimed in any one of the preceding claims, in which the further diaphragm has a lateral dimension which is substantially equal to or greater than twice a lateral dimension of the cone diaphragm.

19. A loudspeaker as claimed in claim 18, in which the lateral dimension of the further diaphragm is less than three times the lateral dimension of the cone diaphragm.

20. A loudspeaker as claimed in any one of the preceding claims, in which the further diaphragm is substantially rectangular and is mechanically terminated at its edge by a substantially rectangular frame having inside corners which are rounded in a transverse plane.

21. A loudspeaker as claimed in any one of the preceding claims, in which the driver comprises an electromagnetic motor for driving the cone diaphragm.

22. A loudspeaker as claimed in claim 21, in which the driver comprises a chassis defining a substantially frustoconical volume in which the motor is disposed.

23. A loudspeaker substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

ABSTRACT
LOUDSPEAKER

(Figure 1)

A low frequency loudspeaker comprises a conventional electromagnetic cone driver 4 having a cone diaphragm 9 provided with an inner suspension 8 and a role surround 12. The cone diaphragm 9 is connected, between the suspensions 8 and 12, to a flat diaphragm 11 whose ends are mechanically terminated so as not to be entirely free to move.

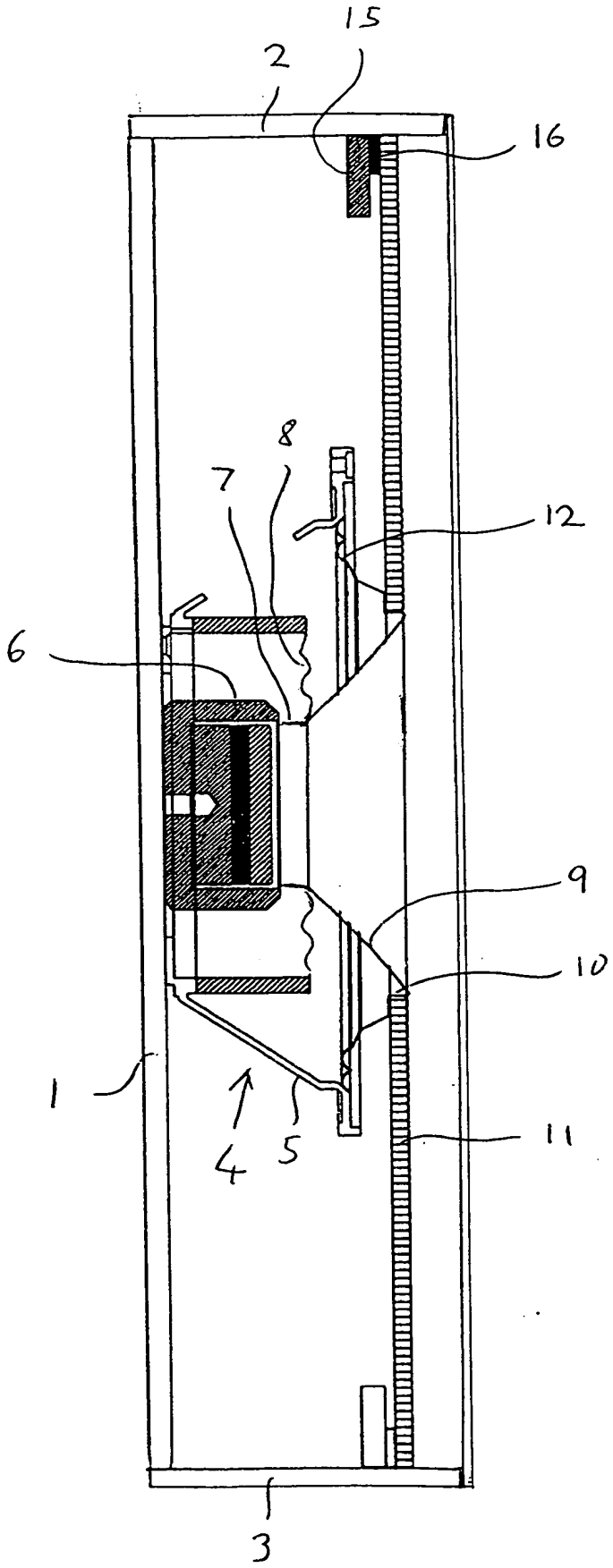

Fig 1

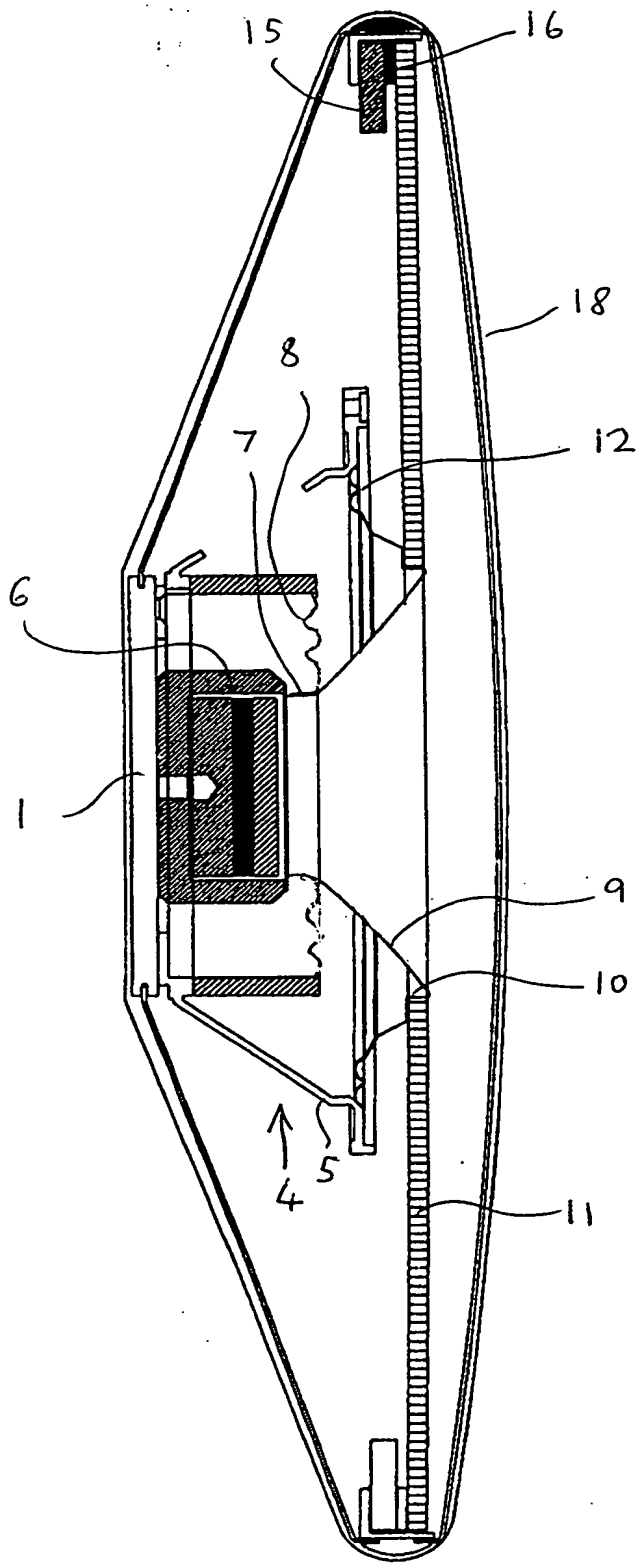

Fig 2

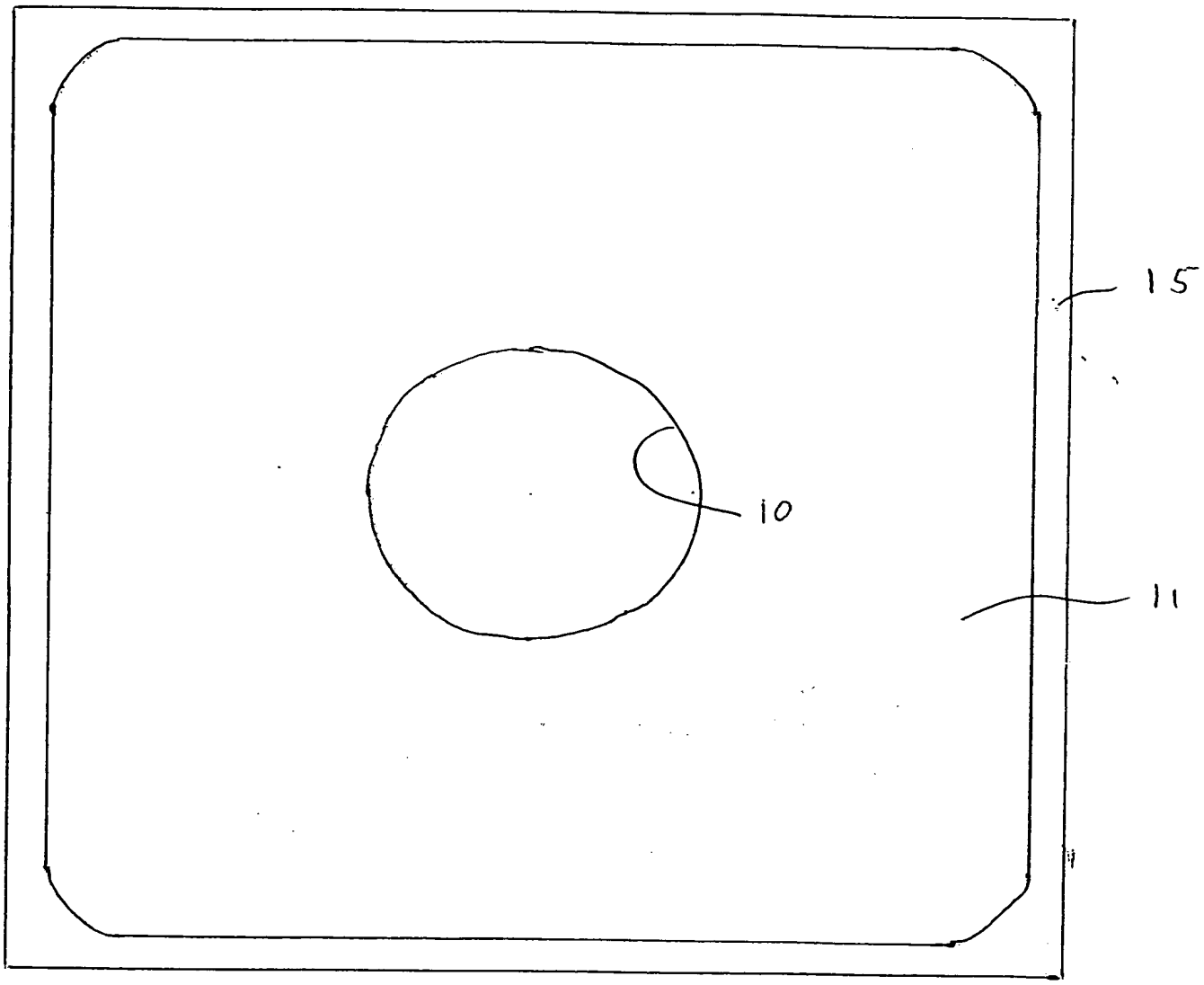

Fig 3

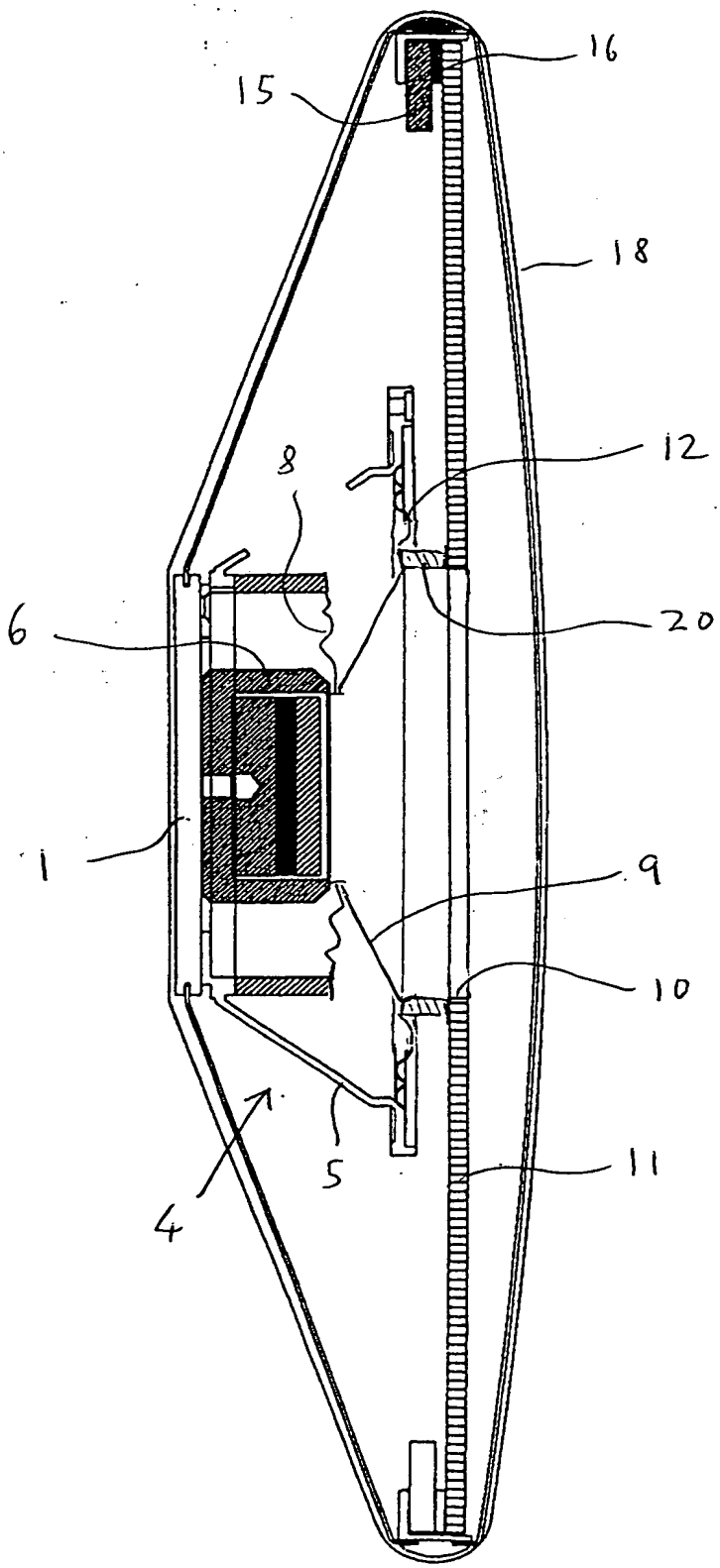

Fig 4